

In Situ Observations of Seismic Events within Fault Zone from TCDP Boreholes Seismometers: FIT related triggered events?

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Taiwan Chelungpu-fault drilling project drilled two holes, 39m apart of hole-A and hole-B, with one branch all crossing the Chelungpu fault to retrieve the fresh slip zone associated with the 1999 Chi-Chi earthquake. The TCDP hole-A is 2 km deep, and a 12-cm primary slip zone (PSZ) at the depth of 1111km was identified. After the successful drilling of the TCDP, the TCDP borehole was used as an in-situ fault zone dynamic observatory. A state-of-the-art 7 level seismometer was installed in the borehole. The 7-level borehole seismometers (TCDP 7-level BHS) were placed crossing the fault zone with three seismometers in the hanging wall, and footwall, respectively, and one seismometer close to the slip zone related to the 1999 Chi-Chi earthquake. A fluid injection test (FIT) was carried out after the drilling and the completed installation of the seismometers to understand the in-situ hydraulic behavior of the fault zone. A high pressure fluid (~4MPa) was injected in hole-B with chemical and gas observations and monitoring in hole-A. The high resolution of TCDP 7-level BHS recorded several different types of events. A significant feature is the observation of three repeating events in 10 sec with almost identical waveforms in S-waves. The travel time differences of S-wave to P-wave ($t_s - t_p$) are 1.60sec, 1.57 sec and 1.38 sec, respectively, for the three events, suggesting a possible propagating crack. The waveform simulations of the observed repeating events with harmonic wave trains after S-wave suggest these events were probably from the fault zone, which is about 190m below the major slip zone. Another observed feature is a pulse like wave, which have an apparent velocity of about P-wave velocity (4km/sec), was observed in TCDP 7-level BHS. Whether this event is in an association of a new open crack after high pressure Fluid Injection Test (FIT) was examined. With the high resolution TCDP 7-level BHS and FIT in an active fault zone, we try to understand dynamics of the fault zone and the estimation on in-situ permeability from FIT related triggered events.